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REPORT

Northern Municipal Services

Whiteswan Lake Spill Elevation Study

JANUARY 2024

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1 INTRODUCTION

Associated Engineering (Associated) was engaged by The Ministry of Government Relations, Northern Municipal Services (the District) to assist in assessing the spill elevation of the combined Whiteswan Lakes in order to better define the potential limits and risks associated with the historically rising lake water levels and potential affects that may be experienced by the Resort Subdivision of Whelan Bay (a community within the District) and the adjacent Recreation Site, (parkland under the jurisdiction of the Ministry of Parks, Culture and Sport).

The Whiteswan Lakes watershed can be described and considered as a closed or semi-closed basin as they do not have a consistent outflow, as such, the water levels continue rising until a poorly defined spill elevation is reached. It is understood that the lake levels have been rising over the past 20 years. A basic review of satellite imagery indicates a decline in visible sandy shores since 2009. While no historical lake level data exists to perform frequency analysis, the 15-year satellite imagery does indicate a trend and reinforces the observed concerns identified by residents.

The primary concern noted by residents is the proximity of the rising water in relation to the privately owned cabins at the south end of Whiteswan Lake. Residents have also expressed concerns over the loss of recreational beaches. It can be seen in Figure 1, 2003 to 2023, the change in water levels and the lake boundaries over that time frame. There has been a significant loss of shoreline noted by the visible sandy areas in the 2003 imagery compared to the 2023 imagery, where no visible sandy areas exist. This is evident when onsite, where the water levels are approaching the lakefront cabins along Shoreline Drive, and residents have reported a significant loss of beaches and an increase in water levels of (reportedly up to 5 meters) in that time frame. A portion of the access road to the subdivision has been relocated as a result of rising water levels at a cost to the Province of Saskatchewan of ~$1.3M. This project was undertaken in 2017 after many attempts to build up and secure the access road continued to fail due to rising water levels. As the water level has been increasing and approaching the elevation of the other built-up areas in the Whelan Bay Subdivision, there is growing concern of loss of property and damages due to flooding. As a result, the District applied for funding under the Flood Damage Reduction Program through the Water Security Agency (WSA) and was approved for funding this study in early 2023.

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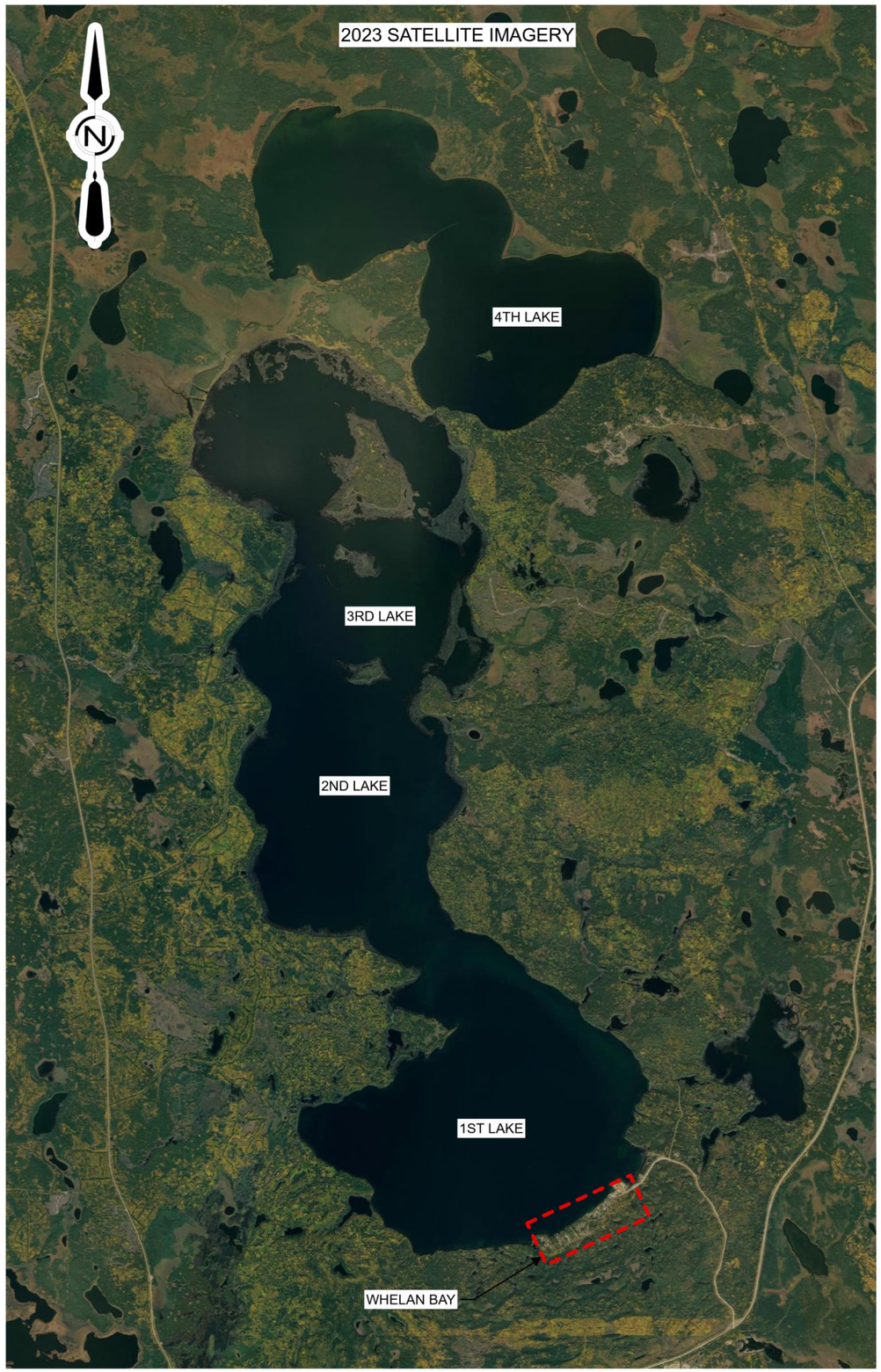

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TOP 5 BEST MANAGED COMPANIES
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FIGURE 1

WHITESWAN LAKE SPILL
ELEVATION STUDY

WATER LEVEL CHANGE
2002-2023

AE PROJECT No.	2022-4823-00
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APPROVED	D. RINAS
DATE	2024JAN30
REV	0
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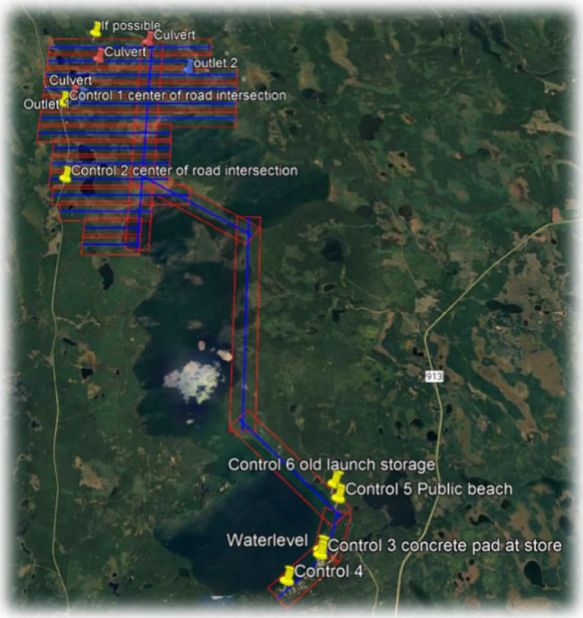
1.1 Background Data

In order to better assess the limits of rising water elevations and the potential for relief, Associated drew on several sources of information. Prior to the initiation of this project, a cursory review of available information was completed by a few volunteers in the community, including Rod Geddert from GeoFocus, who completed a review of the available ortho imagery to assemble a photogrammetric survey of the lake levels and potential spill points in 2021. This review provided a foundation for the current LiDAR study as it showed the potential risk of flooding in the community. However, the data used to complete the survey was not accurate enough to make any reasonable determinations of flood risk, as the error in the base data was noted to be in the range of up to 2 meters, which created significant uncertainty in the actual risk of flooding. This study was the catalyst to obtain more accurate data and complete a more detailed analysis of the flood risks.

Associated used several sources of data for the analysis, which are described below:

- LiDAR
  - LiDAR was collected by GeoFocus for areas determined around the boundaries of the Whiteswan Lakes that would benefit the study of the potential spill elevations. These locations were determined with the assistance of GeoFocus following the previously noted photogrammetric survey analysis. LiDAR was chosen for the data collection method for ground elevations in order to get the most accurate data in such a large and remote area cost-effectively. The timing of the LiDAR data collection was completed in the spring before the leaves were out on the trees and after snowmelt. Data acquisition occurred between May 16th and 19th, 2023. The areas that were captured include the Resort Subdivision of Whelan Bay, along the eastern shorelines of the lakes and the potential northern outlet locations from the third and fourth lakes. The total area collected was approx. 50 km2, and the area collected is shown in the adjacent figure. The data was calibrated with multiple flight patterns of control areas and correlated with control points that were collected during the ground survey.



LiDAR Collection and Ground Control

- Ground survey
  - A GPS ground survey was collected in select locations within Whelan Bay in order to assess the water level, determine shoreline cross sections, define road elevations and determine cabin elevations in relation to the water levels for cabins that were perceived to be at risk of flooding. Ground survey was also completed at select locations northwest of the lakes along the MacDonell Road; culverts crossing the road and beaver dam locations that were accessible on foot were recorded. The GPS ground survey data was correlated to the LiDAR data in order to create an accurate representation of the ground elevations in relation to the water levels that were recorded at the time of the survey.

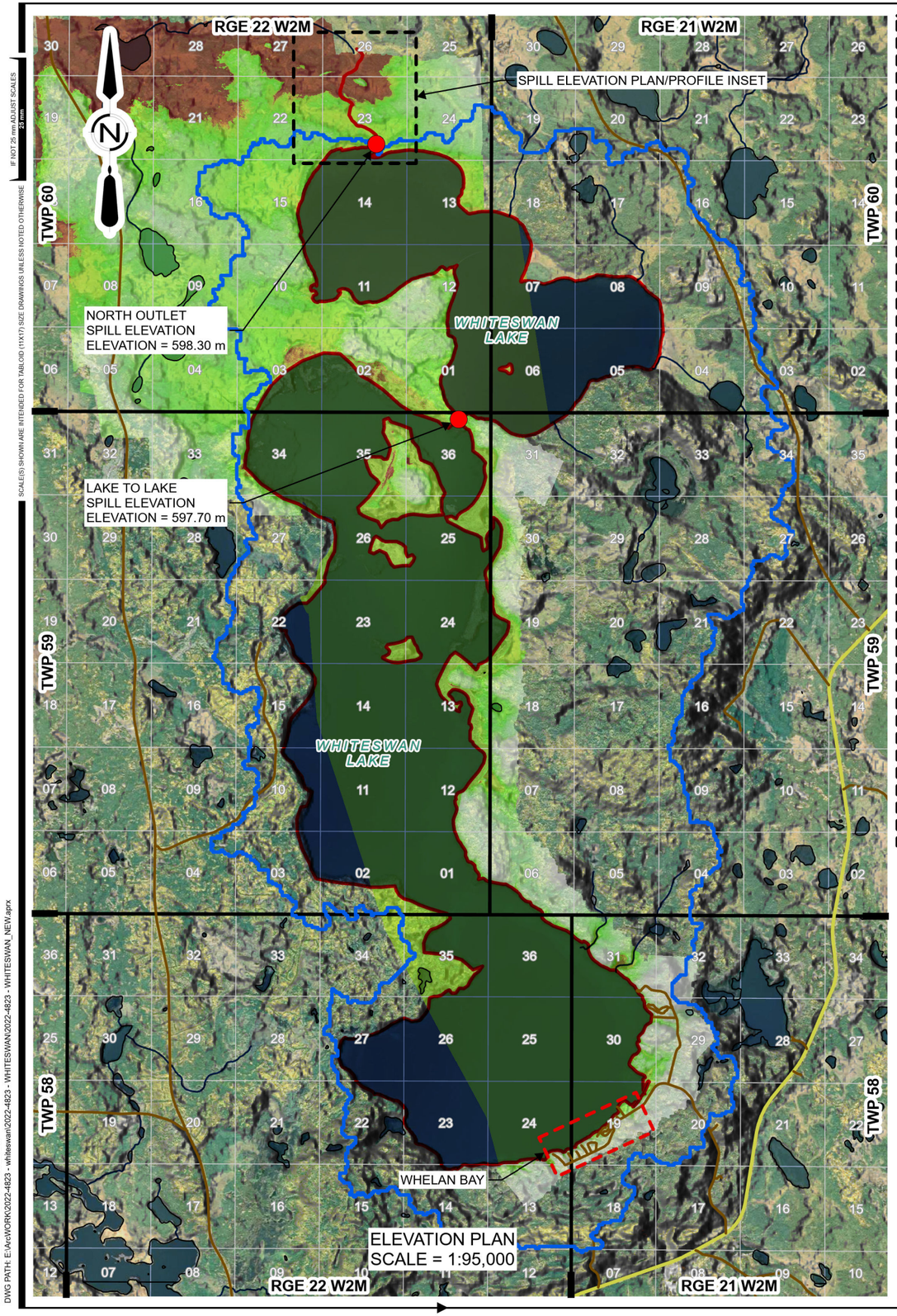
- NASA Earth model data
  - Publicly available earth elevation model that is reasonably accurate and useful for overall estimations of watershed effects when combined with modelling exercises. This data was used to gain an understanding of the overall size of the watershed that contributes to the Whiteswan Lakes; however, it is not accurate enough to determine the potential spill elevations of the lakes that were sought after through the study.
- On-site examination
  - We have had several site representatives observe, take measurements, and investigate the boundary of the lake from the water and surrounding roads.
- Other publicly available information
  - Google Earth Imagery has a considerably broad section of years available, many showing sandy shorelines.
  - Nautical Bathymetry, which leads to some rough estimations regarding wave run-up and may be of value should a wave analysis come in the future.
  - Water Security Agency drainage basin data.

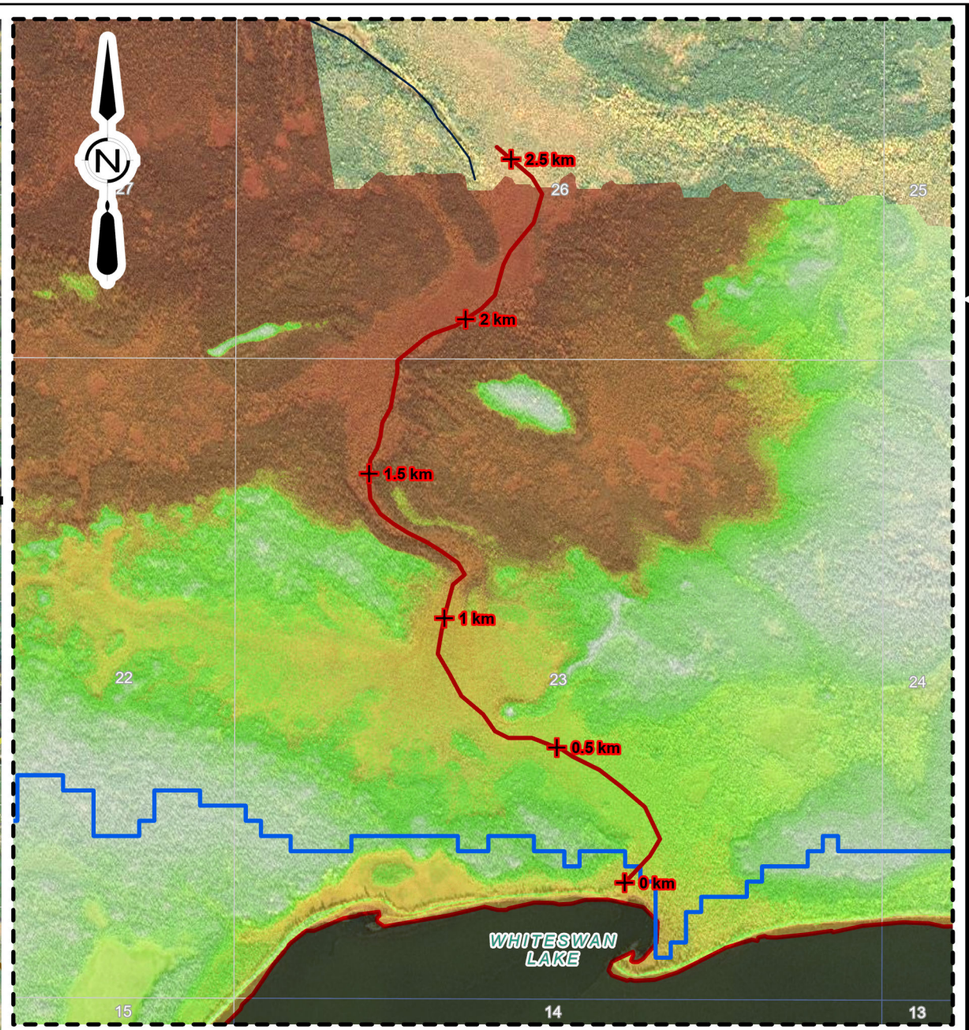
2 ANALYSIS

The goal of the study was to determine the spill elevation of the lake. The data collection noted earlier has been analyzed in the following sections of the report.

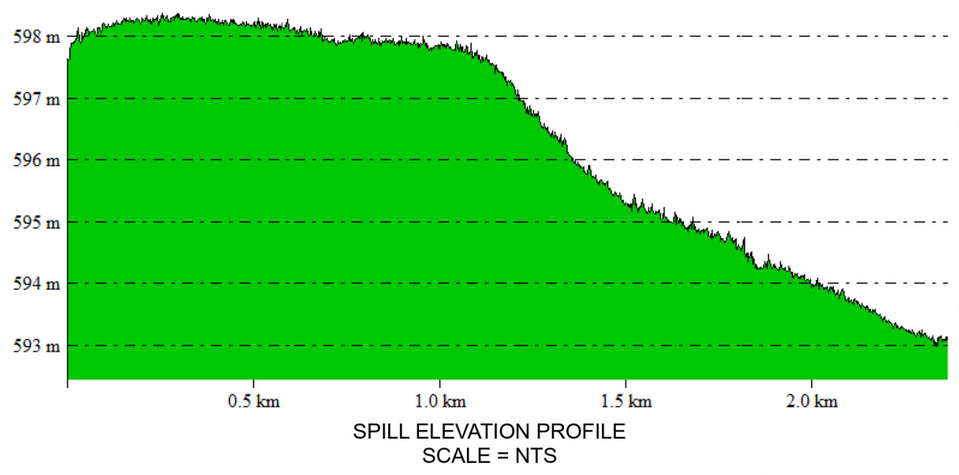
2.1 Lake Water Levels

Figure 2 shows the extent of the LiDAR data and the resultant elevation scale by colour, where green indicates a higher elevation and red the lower. The LiDAR verified that a spill elevation does exist on the boundary between the 3rd and 4th lakes. This location has been observed by locals to flow between the third and fourth lakes in either direction depending on the water elevation in each lake and has been passable by boat in recent years.





SPILL ELEVATION PLAN
SCALE = 1:15,000



SPILL ELEVATION PROFILE
SCALE = NTS

LEGEND:

- ALIGNMENT
- CONTRIBUTING AREA
- WHITESWAN LAKES
- PRIMARY ROAD
- SECONDARY ROAD
- TOWNSHIP
- SECTION

ELEVATION

643.78 m

585.05 m

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FIGURE 2

WHITESWAN LAKE SPILL
ELEVATION STUDY

PLAN/PROFILE
LAKE ELEVATION AND SPILL ELEVATION

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There is also a broad, less defined tipping area that exists on the north boundary of the 4th lake.

Some notable points immediately apparent from the colour banding are as follows:

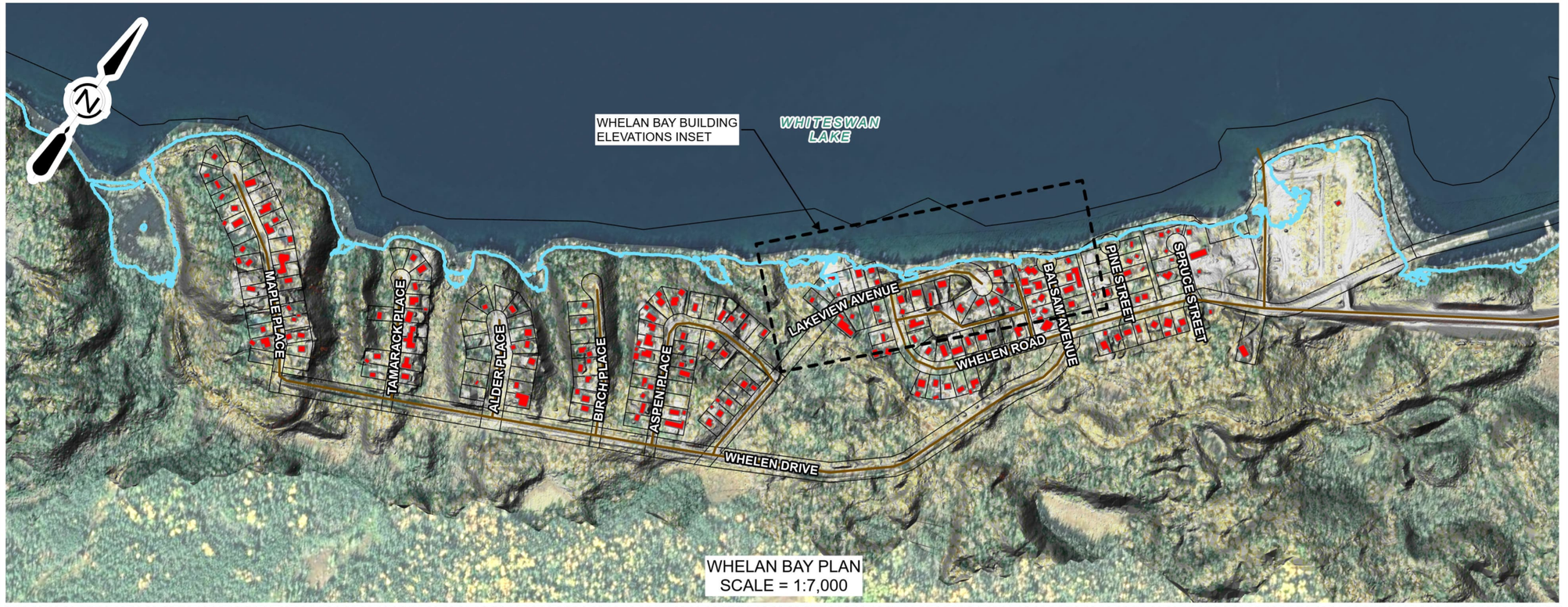
- The overall flow is towards the North. This reflects the WSA defined river basin boundary, where the Whiteswan Lakes are encompassed on the very outside edge (upper limit of) the Churchhill River Basin, which indicates flow eventually progressing to the North West.
- The north boundary of the fourth lake is overall lower throughout than the boundary between the 3rd and 4th lakes, other than the relatively narrow channel where the spill points are anticipated to be.
- Much of the built up property in the Whelan Bay Subdivision is above the noted spill elevation-, however there are locations in the townsite that are clearly affected, and that it is relatively close overall.
- The small lakes just west of the 4th lake are not able to receive any flow as they are at a higher elevation than the Whiteswan Lakes.

The spill elevation between the 3rd and 4th lakes is 597.70 m, and the spill elevation of the north boundary of the 4th lake is 598.30 m before water can drain to the north. These elevations are based on surface LiDAR and will have a margin of error because the ground is a low-level marshy area; however, it indicates that the north boundary of the 4th lake will be the ultimate control point for the level of the lakes. Further, the water level at the time of the GPS survey and LiDAR (May 2023) shows that the water levels are quite close to that ultimate northernmost elevation. We expect that the maximum water levels have been approached, barring potential upsets in the spill elevations, such as beaver dams, circumstances of shoulder season ice damming or similar, which could temporarily elevate the water levels further.

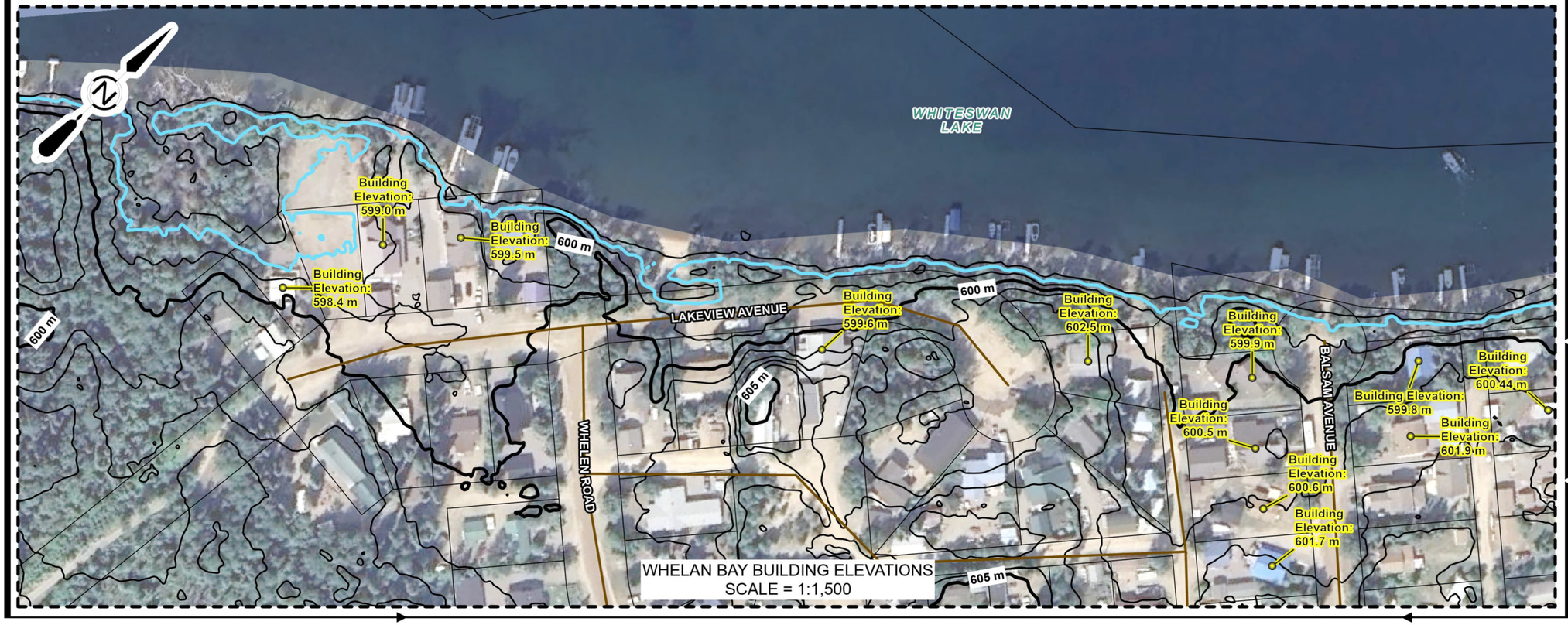
While it is beneficial that the water levels have most likely reached an upper limit, other concerning factors that affect lake elevations and shoreline conditions, most notably to the build up areas, are lake surcharge and wave run-up which can also create potential for ice shove during break up in the spring. Given how close the anticipated water lake levels are to the existing shoreline properties, these conditions should be brought into the ongoing conversation.

2.2 Lake Surcharge

Lake surcharge is the effect of incoming water from surface flows such as snowmelt and rainfall entering the lake faster than it can drain away, infiltrate or evaporate. Defining this potential surcharge is a modelling exercise that encompasses the surrounding contributing drainage area, factored with historic storm duration, severity, infiltration and time of concentration effects. This is beyond the scope of this analysis, but we have performed a basic calculation and included an estimation for discussion purposes. The contributing area of the watershed basin can be seen in Figure 3. For the basis of our analysis, we have included a 100 mm increase in water elevation above the anticipated spill elevation to account for the lake surcharge. This constitutes a considerable volume of water, and unless an upset condition at the spill elevation affects this (such as blockage during a storm) it should be a relatively conservative estimation. This elevation of 598.4 can be seen in relation to the Whelan Bay Subdivision in Figure 3.



WHELAN BAY PLAN
SCALE = 1:7,000



WHELAN BAY BUILDING ELEVATIONS
SCALE = 1:1,500

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LEGEND:

- BUILDING ELEVATION SURVEY
- MAX LAKE LEVEL = 598.40 m (SPILL ELEVATION PLUS 100 mm SURGE)
- BUILDINGS
- WHITESWAN LAKE
- ROADS

FIGURE 3

WHITESWAN LAKE SPILL
ELEVATION STUDY

PLAN
WHELAN BAY MAX LAKE ELEVATION

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2.3 Wave Run-Up

Wave run-up is expected to be a more significant concern to the built up areas. Expected wave run-up can again be calculated by direct calculation or more accurate computer modelling. The conditions that affect wave run-up are wind severity and direction, but additionally, the shoreline slopes both above and below the waterline. This is again beyond the scope of this analysis, but it should be noted that the subdivision is located in the direction of the predominant prevailing winds and has portions of shoreline that are not favourable, and which have been further eroded in recent years due to the effects of waves and water level rise.

Wave run-up should not be ignored over the long term, given the location relative to predominant winds at the Whelan Bay Subdivision; it has the potential to cause further erosion damage to the shoreline and as a result cause flood damage to property if high water levels persist and no action is taken to preserve the shoreline. While this may sound overly conservative, it should be noted that a major wind event is likely to be connected to a surcharge event during a major storm and, additionally, that wave effects are common on large lakes. While a formal analysis of wave set-up is outside the scope of this project, it shows the potential to further erode the shoreline and allow water to approach buildings in the Subdivision in extreme weather events, which could adversely affect the built-up properties.

2.4 Flood Risk Areas

Based on the information and analysis, we have defined zones of concern. While this should not be construed as absolute based on this reports rough estimations of lake effects, it does show the subdivision most likely has cabins, infrastructure and shoreline at risk. While some assumptions can be made in terms of which areas are at risk, it would be prudent to complete further analysis on the affects of lake levels combined with wave run-up and lake surcharge to determine the risk more clearly. Obvious risk areas are going to be the more low-lying lands; however, wave run-up effects are more the concerning aspect at the high water elevations as noted, and a true analysis of wave effects is likely to show that areas with gentle slopes are going to be more effected than areas with steep slopes, which act as barriers to slow the waves.

The cabins that are perceived to be at the highest risk have been shown on Figure 3 and tabulated below in Table 2-1 to show the proximity of the high-water level to the cabins with the exposed building elevations recorded above grade. More ground level elevations are noted in the figure and show the extent of the potential for flood damage to occur in the lower elevation areas. It should be noted that we could not determine if cabins had basements or not, however it has been reported that some properties with basements may be experiencing problems due to the high water levels. The Figures have not considered wave run-up on the shoreline, and further analysis would likely indicate further risk to property due to the prevailing wind directions and potential for shoreline erosion to cause damage to property.

Table 2-1 Elevations of Spill elevations and Lowest Cabin Elevation

Location	Elevation (m)
Lake 3 to 4	597.7
North Outlet	598.3
Lowest Cabin Surveyed	598.4

3 CONCLUSIONS

At this time, the remediation options are very broad, but general points to consider can be made. The subdivision has a level of risk, which has been evident to the residents directly. While there is evidence to suggest that the high water level may have peaked, it has not been confirmed, and further analysis is required to determine the overall affects of lake levels combined with surcharge and wave run-up. Further studies may determine if lowering lake levels, building berms or other temporary measures could be employed to protect property and infrastructure. Further study could assist decision makers in determining the most cost effective approach to mitigating property damage in the future.

Potentials include:

- Lower the lake spill elevations through constructed works;
- Construction of either permanent or temporary wave abatement measures on the shoreline (berms or sandbagging if high water levels persist and further shoreline erosion is experienced; and
- Policy establishment.

Lowering lake levels could have potential hurdles, primarily with cost and environmental regulatory needs. Given that the lake is both a shoreline and fish habitat and that the increasing water levels are most likely still within the definition of natural fluctuation, lowering the water level will most likely be defined as destroying/modifying habitat by regulators. As considering this option is outside the scope of this project, we have not completed an analysis of potential costs for such a project or the potential environmental requirements.

Other considerations exist, such as the ability to work in the areas of the spill elevations, as the 4th lake spill elevation drains into a marshy flood plain, which will require a significant length of trenching in order to effectively lower the lake or stop it from rising beyond a lower elevation that it does currently. This constructed work would additionally require ongoing maintenance to ensure blockages and vegetation growth do not reverse the effects, indicating access would be required to the site for both construction and ongoing maintenance of the area. This is something that could be considered as water levels could drop in the future due to drought conditions, and constructing a lower outlet may not be seen as reducing habitat or draining the lake.

Another approach may be constructing abatement measures, this has been done in other communities facing similar problems and can take the form of sandbagging as a temporary measure or berms as a permanent measure for wave abatement installations.

Berms with blockable back drainage culverts have been used in similar locations to hold back a lake's upper elevations when they occur and to a degree block waves and ice, which may spill over at times but will help the waves lose some of their energy. The culvert blockages must be managed based on season (spring thaws) and lake elevations (closed when high, open when low).

Communities that adopt berms often have higher potential water elevations and lake levels that fluctuate seasonally so that drainage can occur. The berms can be made into walking paths and hidden to a degree, but to block wave run-up, they can't be overly shallow. Additionally, they can have issues with spring thaw waters being trapped, and this leads to necessary raising of structures and lot elevations in their vicinity to accommodate drainage in the long term.

Further to these technical issues wave abatement measures would be similarly placed on the shoreline as a bermed approach but would consist of energy-dissipating measures as opposed to solid earth. One potential option would be rows of riprap that would break down the wave run-up before it could reach areas of concern. The benefit is that they would require much less maintenance, as water would flow back and forth through them. They have a similar drawback to building berms by being unsightly, but given they would be rock or potentially specific bioengineering plantings, it may not be as broadly visible.

Policy establishment is another approach to take. As the analysis shows, the lake has experienced the highest water elevations in recent history and experienced significant run-off and storm events that would create worst-case scenarios. A do-nothing approach still leaves potential for future risk as we have noted, where the potential for high water levels combined with wave run-up could further erode shorelines.

4 RECOMMENDATIONS

The purpose of the study was to determine the potential high water elevation of the Whiteswan Lakes, and the analysis has shown that the high water elevation has potentially been reached, or very close to it, in recent years of high water levels. The options noted above are not to be concluded as an exhaustive list, nor have they been sufficiently vetted to make future decisions; however, they are intended to show what is possible as the stakeholders consider the future impact of flooding in the area. If there is an opportunity to lower the elevation of the spill elevation from the 4th lake without draining the lakes, it could potentially be more cost-effective than building berms in times of emergency. Any consideration of future work to lower the lake level for the benefit of the affected area would require additional analysis and further review of regulatory concerns, along with a higher degree of understanding the implications to upstream and downstream conditions.

Further investigations could include the following if the stakeholders wish to pursue this further:

- The risk associated with wave run-up could be further investigated to determine the long-term effects of the high water elevations on the built up areas
- Feasibility and environmental analysis of lowering the spill elevation from the 4th lake
- Cost analysis of sandbagging and ultimately installing berms to protect the affected properties in a time of emergency in comparison to lowering the spill elevation
- Policy establishment for any new development in low lying areas to include an engineering review for the recommendation of a safe building elevation

Respectfully submitted,

Prepared by:

Darrell Rinas, P.Eng.
Project Manager

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Reviewed by:

Alicia Masserey, P.Eng.
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Date: January 31, 2024